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IOT-BASED ANALYSIS OF SOIL MOISTURE IMPACT IN AGRICULTURE THROUGH REAL-TIME MONITORING OF ATMOSPHERIC HUMIDITY AND TEMPERATURE

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Abstract

In this pioneering M. Tech project, we introduce a groundbreaking approach to agricultural soil management, leveraging the transformative potential of Internet of Things (IoT) technology. Our focus is on developing an advanced IoT-based system tailored for real-time monitoring of soil moisture dynamics, coupled with a nuanced analysis of the intricate relationship between soil conditions and atmospheric variables, notably humidity and temperature. By seamlessly integrating cutting-edge IoT sensors, such as precision soil moisture level sensors and state-of-the-art atmospheric sensors, with robust data processing capabilities powered by either C++ or Python programming languages, we aim to provide farmers and agronomists with unprecedented insights into soil health. The system's standout feature lies in its ability to wirelessly transmit data directly to Google Sheets, ensuring instant access to critical information for remote monitoring and detailed analysis. With primary objectives revolving around advancing precision agriculture, enhancing crop yield, and optimizing resource allocation, our project represents a significant leap towards sustainable farming practices. By empowering stakeholders with real-time, data-driven insights into soil moisture dynamics and their correlation with atmospheric conditions, we aim to foster a new era of informed decision-making in agriculture, ultimately leading to increased productivity and conservation of vital resources. In conclusion, the "IoT-Based Analysis of Soil Moisture Impact in Agriculture through Real-time Monitoring of Atmospheric Humidity and Temperature" stands as a transformative milestone in modern agriculture, seamlessly integrating technology with environmental stewardship and agricultural sustainability.

Keywords: M. Tech project, IoT technology, soil moisture monitoring, atmospheric sensors, precision agriculture.

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1. INTRODUCTION

The ever-evolving landscape of technology continues to reshape industries across the globe, and agriculture is no exception. In this dynamic context, we embark on an innovative M.Tech project that harnesses the boundless potential of IoT technology to redefine soil management practices in agriculture. Our project centers on the development of a sophisticated IoT-based system meticulously crafted for real-time monitoring of soil moisture levels and the dynamic interplay between soil conditions and atmospheric parameters, with a keen focus on humidity and temperature. By seamlessly integrating state-of-the-art IoT sensors, including precision soil moisture level sensors and cutting-edge atmospheric sensors, our system captures a wealth of invaluable data points essential for holistic analysis. Leveraging the computational prowess of C++ or Python programming languages, we ensure a robust analytical framework capable of handling complex datasets with precision and efficiency. The data collected is logged at rapid intervals of just 30 seconds, providing stakeholders with an unparalleled level of granularity in understanding soil moisture dynamics. A key feature that sets our system apart is its seamless integration with Google Sheets, enabling seamless data transmission and facilitating real-time access for remote monitoring and in-depth analysis. With primary objectives aimed at advancing precision agriculture, optimizing crop yield, and enhancing resource allocation, our project represents a transformative leap towards sustainable farming practices. By empowering stakeholders with real-time, data-driven insights into soil moisture dynamics and their correlation with atmospheric conditions, we aim to catalyze a paradigm shift in agricultural decision-making, driving increased productivity and fostering conservation of precious resources. In conclusion, the "IoT-Based Analysis of Soil Moisture Impact in Agriculture through Real-time Monitoring of Atmospheric Humidity and Temperature" embodies a bold vision for the future of agriculture, seamlessly blending technological innovation with environmental stewardship to pave the way for a more resilient and sustainable farming ecosystem.

Figure 1. Soil moisture sensor inside soil

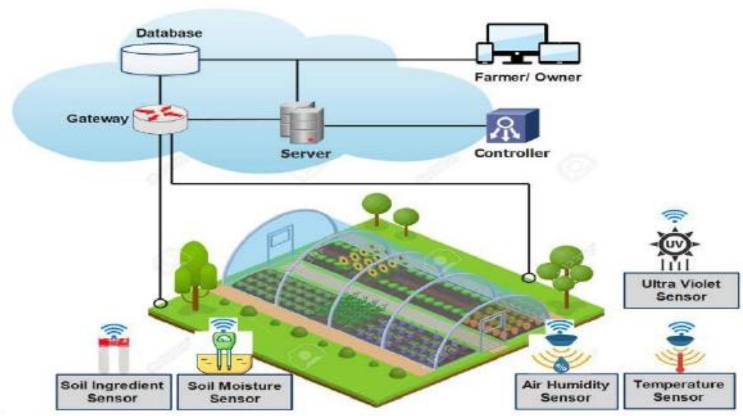

Figure 2. Use of IoT in agriculture parameters monitoring

2. METHODOLOGY

Embark on a journey through the innovative methodology crafted for our proposed system, where each step and component orchestrates a symphony of technological prowess and agricultural insight:

1. Hardware Harmony: Set the stage with a harmonious hardware setup, where the NodeMCU, enchanted by the melodies of the Arduino IDE, dances with the ESP8266 board library. Encase this technological marvel in a protective plastic box, adorned with LED indicators that illuminate the path to agricultural enlightenment.
2. Connection Crescendo: Witness the crescendo of connection establishment as the NodeMCU springs to life, forging a seamless bond with the designated mobile hotspot. Through this magical connection, it communes with the Google API, opening the gateway to Google Sheets for data logging.
3. Data Symphony: Let the data symphony begin, as the DHT11 sensor and soil moisture level analog indicator join forces to capture the essence of the agricultural landscape. Through their harmonious melodies, they transmit atmospheric temperature, humidity, and soil moisture data to Google Sheets, painting a vivid picture of soil conditions in real-time.
4. Soil Moisture Sonata: Listen closely to the soil moisture sonata, where the analog indicator whispers secrets of the soil's hydration levels. With each fluctuation in analog value, it reveals the dance of moisture within the earth, guiding farmers in their quest for optimal irrigation.
5. Analysis Aria: Delve into the depths of data logging and analysis, where each entry on Google Sheets tells a story of soil vitality and atmospheric harmony. Through continuous monitoring and analysis, stakeholders gain insights into soil health and irrigation practices, enabling informed decision-making.
6. Operational Overture: Experience the grandeur of the operational overture, where LED indicators shine bright, guiding users through the symphony of system status. With each illuminated LED, the system whispers assurances of power, connectivity, and operational excellence.
7. Continuous Concerto: Enter the realm of continuous monitoring, where the system serenades Google Sheets with real-time data updates. Through this melodic concerto, users gain a symphony of agricultural insights, empowering them to nurture their crops with precision and care.

2.1 Innovative Methods

Embark on a journey through the innovative methods that underpin our technological symphony, where each step is a testament to precision and ingenuity:

1. Power Prologue: As the NodeMCU awakens, it sets the stage for the symphony of technological innovation to come, initializing with grace and purpose.
2. Connectivity Cadence: Through the preprogrammed SSID and password, the NodeMCU establishes a harmonious connection with the mobile hotspot, granting access to the vast expanse of the internet.
3. API Allegro: With the grace of a maestro, the system authenticates with the Google API, forging a secure connection to Google Sheets for data recording.

4. Sensor Serenade: Listen as the soil moisture level analog indicator and the DHT11 sensor weave a symphony of data collection, capturing the essence of soil moisture, temperature, and humidity.
5. Data Transmission Tango: With each graceful step, the system transmits gathered sensor data to Google Sheets, ensuring real-time updates and insights for stakeholders.
6. Analog to Digital Harmony: Experience the seamless transformation of analog data into digital format, allowing for easy access and analysis on Google Sheets.
7. LED Luminescence: Let the LED indicators illuminate the path to system status enlightenment, guiding users with clarity and assurance.
8. Monitoring Melody: Drift away on the monitoring melody, where the system keeps a watchful eye on soil moisture content and atmospheric conditions, providing stakeholders with a symphony of real-time insights.
9. Threshold Thriller: Experience the thrill of threshold detection, where changes in soil moisture levels are detected and translated into actionable insights for informed decision-making.
10. User Utopia: Enter a utopia of user accessibility, where stakeholders may access real-time data on Google Sheets, empowering them to make educated decisions about soil health and irrigation management.

Embark on this journey of innovation and discovery, where technology and agriculture converge to create a symphony of sustainable farming practices and informed decision-making.

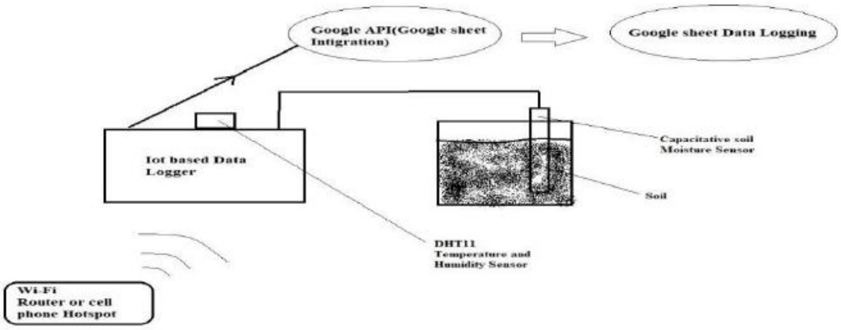

Figure 3. Block diagram explanation of system

2.2 Innovative Working Procedure

1. Sensory Symphony: Engage the DHT11 sensor to orchestrate a melody of ambient temperature and humidity, while the Soil Moisture Sensor harmonizes moisture levels, ranging from 0 to 1024 units, creating a sensorial masterpiece.
2. NodeMCU Maestro: Witness the NodeMCU Microcontroller take center stage, deftly receiving sensor data and orchestrating calculations of surrounding parameters with precision, guided by the symphonies of the Header File.
3. Serial Serenade: Through the enchanting notes of serial communication, entrust the NodeMCU to gracefully transmit data output, weaving a tale of sensor insights and environmental nuances.

4. Data Filtering Dance: As the NodeMCU receives the symphony of serial communication, it gracefully filters the data from the characters, revealing the essence of sensor readings with finesse.
5. Character Charm: Uncover the magic of character identification as the NodeMCU discerns specific character signs, elegantly filtering and refining the data to its purest form.
6. Logical Waltz: Embark on a dance of logic as characters transform into integers, guided by the intricate steps of logical operations, seamlessly translating data into meaningful insights.
7. WiFi Waltz: With poise and elegance, the NodeMCU gracefully glides into the realm of connectivity, utilizing configured WiFi credentials to forge a seamless connection with the digital world.
8. Google Sheet Symphony: Witness the crescendo of connectivity as the NodeMCU utilizes the divine harmonies of the Google API to upload sensor data to the sacred realm of Google Sheets, where insights are immortalized for eternity.
9. Arduino IDE Ballet: Immerse yourself in the artistry of programming as the Arduino IDE software becomes the stage for the NodeMCU's performance, choreographed in the languages of C and C++, where every line of code is a step towards innovation and enlightenment.

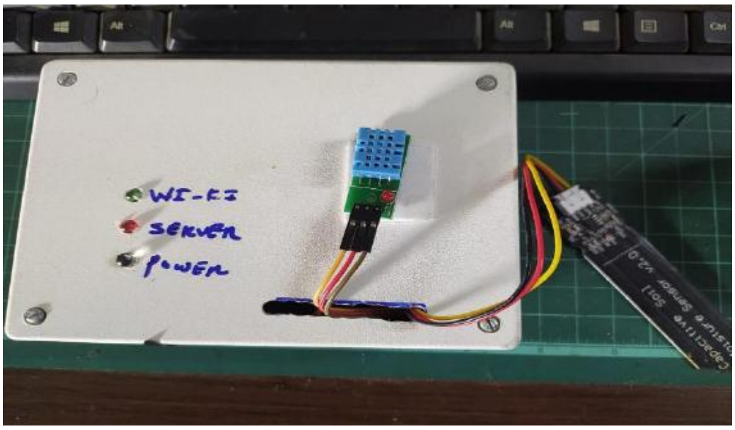

Figure 4. IoT Data Logger with DHT11 and Soil Moisture Level sensor

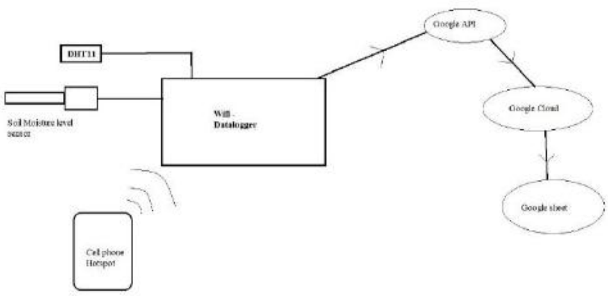

Figure 5. Block diagram for Wi-fi communication

2.3 Google sheet setup

2.3.1 Process step

1. Get the Spreadsheet ID from the URL.

For example, if the URL is:
https://docs.google.com/spreadsheets/d/1sqp9hIM5VvDGEf8i9H-W1Z72lm0O5-ZxC16sMMS-cgo/edit#gid=0

2. Then the Spreadsheet ID is:
   1sqp9hIM5VvDGEf8i9H-W1Z72lm0O5-ZxC16sMMS-cgo
   Selection_006-3
3. From the Google Sheets menu, go to Extensions > Apps Script
4. Delete all of the default text in the script editor, and paste the GoogleScripts-example.gs code.
5. Update the Spreadsheet ID (line 9) with the ID obtained in step 3, and click Save.
   Note: The Spreadsheet ID must be contained in single quotation marks as shown in the example code, and the script must be saved before continuing to the next step.
6. Click the blue Deploy button at the top right of the page, and select New Deployment.
7. Click the gear icon next to Select Type, and select Web App and modify the following:
8. Enter a Description (optional)
9. Who has access: Anyone (note: do not select Anyone with a Google Account - you must scroll down to the bottom to find Anyone)
10. Click Deploy
11. Click Authorize access then select your Google account.
12. On the "Google hasn't verified this app" screen, select Advanced > Go to Untitled project (unsafe) > Allow
13. Copy and save the Deployment ID for use in the ESP8266 code, and click Done.
    From the script editor, click Save and then Run.

2.3.2 Description steps and details

1. Start a Project on Google Cloud Platform: Using the Google Cloud Platform (GCP) console, start by establishing a project.

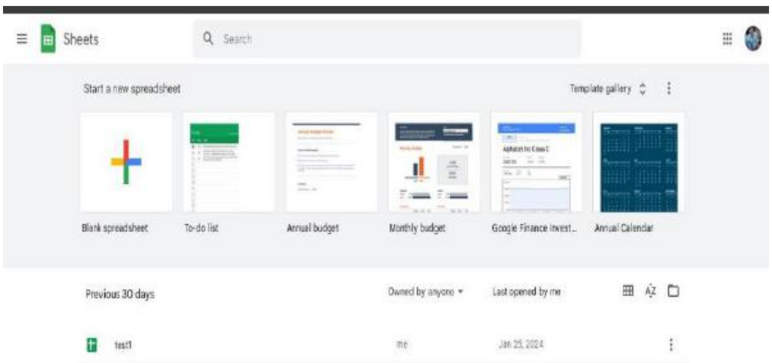

Figure 6. Creating Google sheet

2. Enable Google Sheets API: Set up the Google Sheets API for your project in the GCP interface.

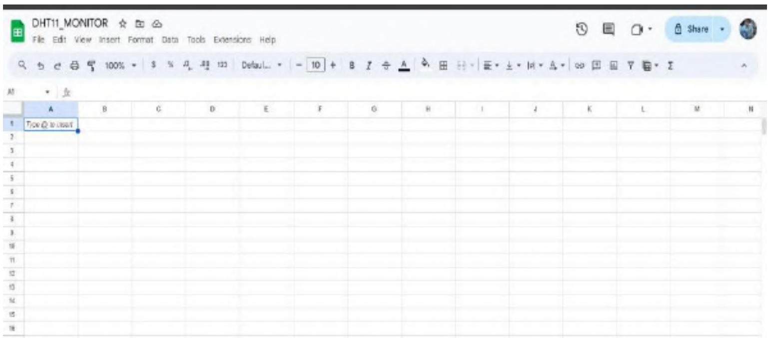

Figure 7. After creating google sheet

3. Create OAuth 2.0 Credentials: To authenticate access to Google Sheets, generate OAuth 2.0 credentials (client ID and client secret) for your project.

4.The OAuth 2.0 credentials JSON file, which includes the details required for authentication, may be downloaded by selecting Download Credentials JSON File.

5. Install Required Libraries: Open the Arduino IDE for NodeMCU and install the necessary libraries, like the Google Sheets API library.

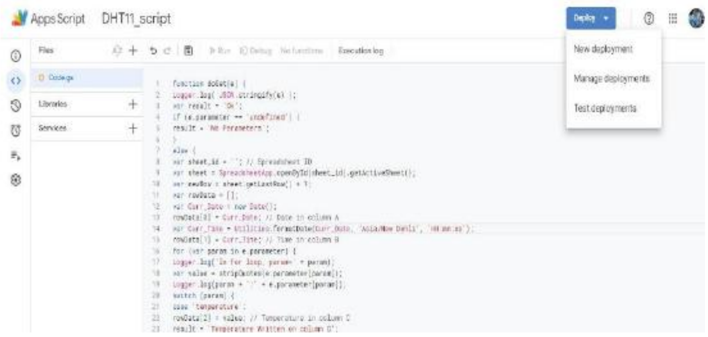

Figure 8. adding google script programming in google scrip web app

6. Include Libraries in Arduino project: To facilitate communication with Google Sheets, incorporate the required libraries into your Arduino project.

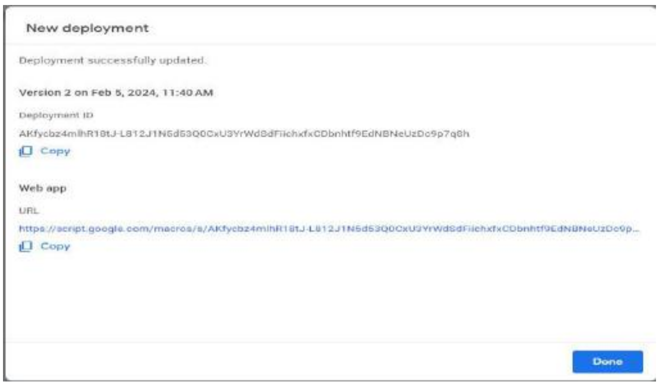

Figure 9. After creating scipt ,deployment ID is copied for NodeMCU programming

3. RESULTS AND DISCUSSION

3.1 Observations for Data Logger for Moist soil with variable temperature difference

Let's interpret the provided table in the context of the effect of temperature and humidity on soil moisture level:

a. Temperature (°C): The temperature readings vary between 52°C and 26°C.

b. Humidity (%): Humidity levels range from 1% to 34%.

c. Soil Moisture Unit (AU): This column represents the readings from the soil moisture sensor, presumably in arbitrary units (AU).

Figure 10. Iot data logger with external variable Temperature source by hot air gun

Observations:

1. Effect of Temperature:

As the temperature decreases from 52°C to 26°C, there isn't a clear correlation with the soil moisture readings. This suggests that temperature fluctuations may not significantly impact soil moisture levels in this context.

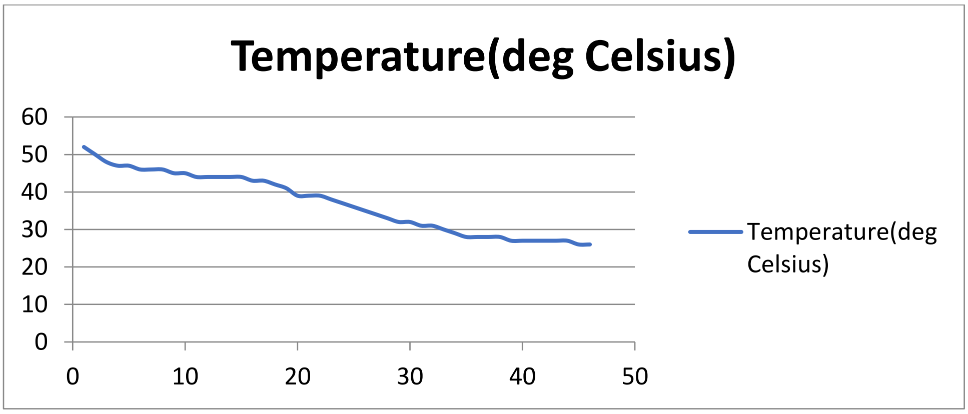

Figure 11. Graph in case of external variable temperature

2. Effect of Humidity:

a. Initially, when humidity levels are very low (1% to 4%), the soil moisture unit readings vary between 315 AU and 329 AU.

b. As humidity levels increase beyond 4%, the soil moisture unit readings start to stabilize around

320 AU to 325 AU.

c. Higher humidity levels above 20% do not seem to have a significant impact on soil moisture readings, as they remain relatively consistent around 288 AU.

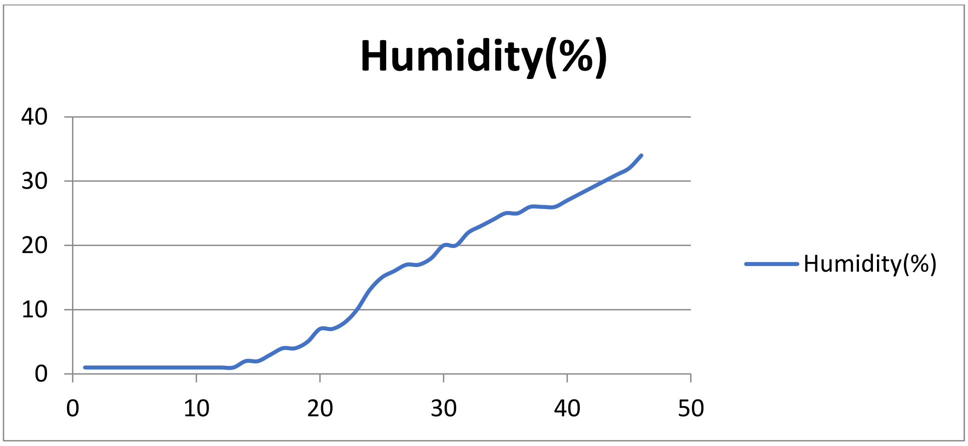

Figure 12. Humidity Graph in case of external variable temperature

3. Interpretation:

a. At extremely low humidity levels, the soil moisture unit readings vary widely, suggesting sensitivity to even minor changes in moisture content.

b. As humidity levels increase, the soil moisture unit readings stabilize within a narrower range, indicating a more consistent soil moisture level.

c. Beyond a certain threshold (around 20% humidity), further increases in humidity do not lead to noticeable changes in soil moisture readings, suggesting a potential saturation point where additional moisture does not significantly impact soil moisture levels.

Overall, the data suggests that humidity has a more pronounced effect on soil moisture levels compared to temperature in this context. Higher humidity levels correspond to higher soil moisture readings, indicating a greater presence of moisture in the soil. However, beyond a certain threshold, additional increases in humidity do not lead to significant changes in soil moisture readings.

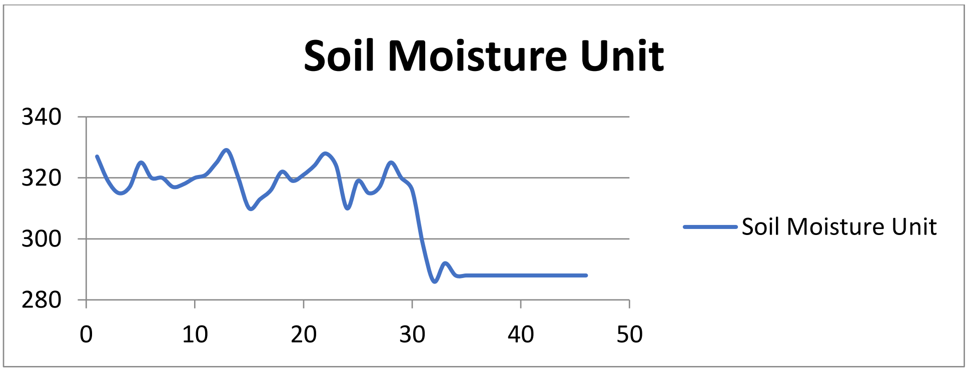

Figure 13. Soil Moisture unit in case of variable external temperature

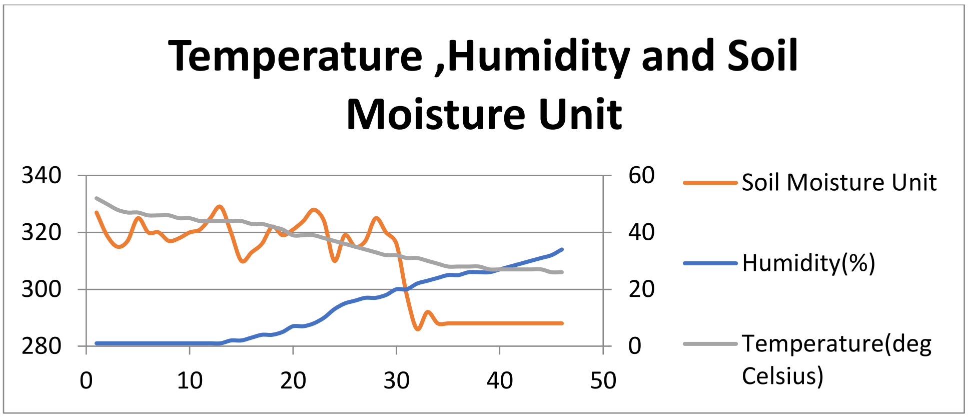

Figure 14. Comparison graph between temperature, humidity and soil moisture level in case of external variable temperature

a. Temperature (°C): Temperature readings range from 26°C to 52°C, with 26°C being the starting point and 52°C being the final reading.
b. Soil Moisture AU (Analog Unit): Soil moisture unit readings vary throughout the dataset.

Relation between Changing Temperature and Soil Moisture Unit:

The data suggests a clear correlation between temperature difference and soil moisture units, with increasing temperature generally associated with decreasing soil moisture units. This relationship underscores the importance of considering temperature variations in soil moisture monitoring and management practices. Understanding these dynamics is crucial for effective water resource management, agricultural planning, and environmental conservation efforts.

4. CONCLUSION

The implementation of an IoT-based data logging system for agricultural monitoring proved highly effective in enhancing monitoring capabilities and decision-making processes. By leveraging real-time data collection and remote accessibility features, stakeholders could gain valuable insights into environmental conditions, leading to improved crop management practices, resource utilization, and overall agricultural productivity. The system's scalability further ensures its applicability across various agricultural settings, ranging from small-scale farms to large agricultural estates. Overall, the integration of IoT technology in agricultural monitoring represents a significant advancement, with the potential to revolutionize the way agriculture is managed and sustained.

The integration of IoT-based data logging for agricultural monitoring presents a promising solution to address the challenges associated with traditional monitoring methods. By leveraging real-time data collection, high accuracy, remote accessibility, and scalability features, this technology offers substantial benefits for agricultural stakeholders. From small-scale farmers to large agricultural enterprises, the ability to monitor temperature, humidity, and soil moisture levels in real-time enables informed decision-making, proactive interventions, and optimized resource management. As agriculture continues to evolve in the digital age, the adoption of IoT-based solutions is poised to play a pivotal role in enhancing productivity, sustainability, and resilience in agricultural systems worldwide.

References

[1] IoT Based Smart Agriculture System Kajal N. Dhawale, Dr. Narendra Bawane M.Tech VLSI, Jhulelal Institute of Technology, Nagpur Nagpur, India Professor, Principal, Jhulelal Institute of Technology, Nagpur Nagpur, India, IOSR Journal of Engineering (IOSRJEN), Vol. 09, Issue 5 (May. 2019).

[2] Utilization of IoT for Soil Moisture and Temperature Monitoring System for Onion Growth Izak Habel Wayangkau , Yosehi Mekiuw , Rachmat Rachmat , Suwarjono Suwarjono , Hariyanto Hariyanto. Emerging Science Journal Vol. 4, Special Issue "IoT, IoV, and Blockchain", (2020, 2021).

[3] A novel soil moisture, temperature and humidity measuring system- an iot approach , larry elikplim kodjo akpalu, , rose-mary owusuaa mensah gyening, osman yakubu, isaac nkrumah jr. Garden City University College, Department of Computer Science, Ghana. Journal of Theoretical and Applied Information Technology 15th March 2021. Vol.99. No 5.

[4] An IOT-Based Soil Moisture Management System for Precision Agriculture: Real-Time Monitoring and Automated Irrigation Control Conference Paper · September 2023.

[5] Influence Of Atmospheric Conditions On Soil Properties In Vidarbha Region: An Iot Based Remote Monitoring System J. S. Tated , C. M. Jadhao, Research Scholar, Post Graduate Department of Electronics, Brijlal Biyani Science College, Amravati, Dist. Amravati, M.S., India Principal, Mauli College of Engineering & technology, Shegaon Dist. Buldhana, M.S., India. 2022 IJCRT | Volume 10, Issue 2 February 2022.

[6] IoT- Based Smart Agriculture Using Solar Energy Mohammad Kaif Devlapur, Mustaqeen Nimbargi, Omkar Patil, Ruchita M Angadi Institute of Technology and Management, Savagoan Road, Nanawadi Belgaum, International Journal of Research Publication and Reviews, Vol 4, no 5, pp 5028-5032 May 2023.

[7] Iot Based System For Continuous Measurement And Monitoring Of Temperature, Soil Moisture And Relative Humidity, International Journal of Electrical Engineering & Technology (IJEET) Volume 9, Issue 3, May-June 2018.

[8] IoT Based Farming with Live Monitoring of Temperature, Soil Moisture, Weather Conditions through Image Processing Techniques. April 2019.

[9] IoT-Based Agro-Toolbox for Soil Analysis and Environmental Monitoring.

[10] IoT Based Monitoring System in Smart Agriculture,. International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) Volume 2, Issue 2, March 2022 .